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Revisionary Studies on Microspore Architecture of Some Indian Species of *Selaginella* Beauv. (Selaginellaceae)

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ABSTRACT: The microspore morphology of five Indian species of *Selaginella* based on colour, laesurae length, ornamentation and size have been revised. In the present study, intraspecific variations in ornamentation patterns of microspores have been reported using Light Microscopy [LM]. These observations would be helpful in morphotaxonomy for accurate identification species, cataloging the basic data of *Selaginella* species and systematics of the genus as well.

KEYWORDS: *Selaginella*; microspore; colour; size; ornamentation.

I. INTRODUCTION

The genus *Selaginella* Beauv. (Spike Moss or Small Club Moss) is one of the cosmopolitan terrestrial genera of pteridophytes and consists of about 750 species (Jermy 1990). It is herbaceous, ligulate and heterosporous lycopod containing both megaspores and microspores.

Megaspores in *Selaginella* have been the subject of wide attention and have been studied in detail than the microspores. The first report on the microspore of *S. kraussiana* (Kze.) A. Br. was made by Millardet (1869) to know the formation of antherozoids. Variation in microspores morphology in *Selaginella* was described by Knox (1950). The microspores have been found to be more diverse than the megaspores as reported in the species of *Selaginella* growing in Argentina (Morbelli 1977) and also in Tropical America (Tryon & Tryon 1982). The sporoderm ultrastructural details of *Selaginella* microspores have been previously studied, from time to time, by different workers using transmission electron microscopy (TEM) (Pfeiffer 1871; Belajeff 1885; Heinsein 1894; Stainier 1965; Pettitt 1966; Robert 1970, 1971a, 1971b; Gullvag 1971; Lugardon 1972, 1976, 1990; Tryon & Lugardon 1978, 1991; Uehara 1999; Morbelli et al. 2001; Rowley et al. 2002; Morbelli & Rowley 2010). Two different types of microspore tetrads in *S. convoluta* (Arn.) Spring and *S. lepidophylla* (Hook & Grev) Spring have been reported which are unique structural diversity of the microspore sporoderm in the genus *Selaginella* (Morbelli & Lugardon 2012). However, only a few studies have been made which will provide a clear idea about their exine surface ornamentation. Moreover, microspore morphology in Indian species of *Selaginella* has been largely studies through light microscopy by Dixit (1992) and SEM study has been mostly neglected. *Selaginella* is one of the diverse genera of lycopods with about 66 species have been reported from India (Dixit 1992; Madhusoodanan & Nampy 1994; Antony et al. 2002; Nisha et al. 2010; Singh et al. 2012) but literature is silent on their complete microspore wall surface describing intra-specific range of variation in colour, size and ornamentation.

The present investigation aims to analyse the ornamentation of microspores in five Indian species of *Selaginella* in order to provide the basic features of their morphology. The findings would be helpful in taxonomy, understanding

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nature of range of the variation within species and relevant to the future studies and interpretations in the systematics of the genus.

II. MATERIALS AND METHODS

The plants of *Selaginella* were collected from different localities of south and central India. Habitat and the morphometric features were noted in the fields. Fresh plant material was fixed in FAA for further examination in the laboratory. The herbarium specimens were prepared from each locality and it is deposited in the Department of Botany, Brahmanand Post Graduate College, Kanpur and Botanical Survey of India, Central Circle, Allahabad, India (BSA).

Fifteen strobili from five plants per population were randomly selected to evaluate the intra-specific variability. Fifteen mature microsporangia were randomly selected from 15 strobili to examine the size of microspore. Fifty microspores (mounted in glycerin jelly), not subjected to acetolysis, were measured in the equatorial plane using LM. Morphometric observations of microspores were taken using LM.

The taxonomy and nomenclature for the identification of species, microspore sporoderm surface terminology and description style of microspores for each species was based on relevant literatures (Alston 1945; Hickey 1986; Dixit 1992; Tryon & Lugardon 1991; Korall & Taylor 2006; Punt et al. 2007; Singh et al. 2014).

III. RESULTS

The findings of the present study include the number, colour, shape (amb), size (range of equatorial diameter), laesurae (type and length), surface ornamentation and micro-sculpture of microspores. The microspore colour, size and ornamentation are compared with the results from earlier studies.

Selaginella ciliaris (Retz.) Spring

Surface: Yellowish brown, trilete microspores with rounded or triangular amb; equatorial diameter 28–39 μm . Wide, straight laesurae covered with spines and extending almost to equator. Both proximal and distal surfaces have echinate ornamentation. Micro-sculpture is echinate.

Note: The microspores of this species have earlier been documented having with largely baculate and clavate ornamentation (Sen et al. 1989) and blunt processes and 30–35 μm diameters under LM (Dixit 1992). Our observations are not accordance with earlier studies except the size.

Selaginella crassipes Spring

Surface: Dark red, trilete microspores with triangular amb; equatorial diameter 29–52 μm . Wide, straight laesurae extending completely to equator. Both proximal and distal surfaces have warty ornamentation. Micro-sculpture is warty.

Selaginella delicatula (Desv. ex Poir.) Alston

Surface: Brown, trilete microspores with rounded amb; equatorial diameter 26–32 μm . Narrow, straight laesurae covered with bacula and extending almost to equator. Both proximal and distal surfaces have baculate ornamentation while bacula is more prominent on distal surface than proximal surface. Micro-sculpture is baculate-echinulate.

Note: The microspores of this species have a diameter of 27.7 μm and spinate sculpture but texture is rough (Dahlen 1988) or largely baculate ornamentation (Sen et al. 1989) and diameter of 20–30 μm with blunt rod-like processes under LM (Dixit 1992). Results of present study are accordance with the previous studies in both microspore size and ornamentation except ornamentation (Dahlen 1988; Dixit 1992).

Selaginella miniatospora (Dalz.) Baker

Surface: Dark yellow, trilete microspores with rounded or sub-triangular amb; equatorial diameter 20–33 μm . Wide, sinuous laesurae completely extending to equator. Both proximal and distal surfaces have verrucate ornamentation. Micro-sculpture is verrucate-ridged.

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Note: The microspores of this species have baculate and clavate ornamentation (Sen et al. 1989) and diameters of 10–30 μm and microspores have verrucoid ornamentation under LM (Dixit 1992). Our observations are not in accordance with previous studies for both microspore size and ornamentation.

Selaginella panchghaniana Dixit

Surface: Dark yellow, trilete microspores with rounded or triangular amb; equatorial diameter 33–67 μm . Wide, sinuous laesurae completely extending to equator. The proximal surface bears verrucate and the distal surface has irregular distribution of verrucae with spines. Micro-sculpture is verrucate–echinulate.

Note: The microspores of this species have diameters of 25–40 μm with verrucoid ornamentation under LM (Dixit 1992). Results of present study accord with previous study for microspore size.

IV. DISCUSSION

The size of *Selaginella* microspores described in the present investigation is mostly accordance with earlier reports. However, the exine ornamentation differs from the previously published works (Dahlen 1988; Sen et al. 1989; Dixit 1992). The microspore colour in these species are variable from the earlier studies except *S. ciliaris*. It was reported that the spore colour are variable within the same species (Hellwig 1969; Korall & Taylor 2006). It appears that the difference in colour, ornamentation and size may be due to one of several factors such as misidentification of specimens at species level or environmental influences on development of microspores or intraspecific morphological variations within the species.

The descriptive style and ornamentation terminology is different from the earlier workers (Dahlen 1988; Sen et al. 1989; Dixit 1992). The terms such as blunt processes, blunt rod-like processes, irregular elevations, spinate and verrucoid used by some workers from time to time (Dahlen 1988; Sen et al. 1989; Dixit 1992) are not acceptable in contemporary literatures. However, in the present investigation, detailed morphological aspects of microspore surface and their exine ornamentation patterns have been described accordance with an internationally acknowledged mode prescribed for taxonomic delineation of species following Punt et al. (2007). The ornamentation of microspores in *S. crassipes*, and *S. panchghaniana* are described for the first time and a new pattern of ornamentation have been reported in *S. ciliaris*.

Further studies on the microspores of these species using TEM and EXRD may provide more information on the microspores. Such studies would be helpful in understanding and comparison of homologous and non-homologous features of microspores. Further, it provides clues to relate the genus to other heterosporous lycopods.

V. CONCLUSIONS

The results of present study provide the basic data of variability in the colour, exine ornamentation, micro-sculpture and size on the microspores of five Indian species of *Selaginella*. It would be helpful in interpreting variability and provides a basic catalogue for analysing the taxonomic features of closely allied taxa of the genus.

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